Journal of Communicable Diseases
Volume 57, Issue 4 - 2025, Pg. No. 115-121
Peer Reviewed & Open Access Journal

Research Article

Measles Vaccination Efficacy: Comparing Disease Severity and Complications in Kyrgyz Pediatric Patients

Elena Khalupko[1], Svetlana Chechetova[2], Zuura Dzholbunova[3], Meerim Baialieva[4], Elena Radchenko[5], Damirakhan Chynyeva[6], Madina Mambetova[7], Gulzhan Omurkulova[8], Cholpon Imankulova[9]

[1-7]Department of Children's Infectious Diseases, IK Akhunbaev Kyrgyz State Medical Academy, Bishkek, Kyrgyzstan
[8,9]Department of Obstetrics and Gynecology named after MS Musuraliev, IK Akhunbaev Kyrgyz State Medical Academy, Bishkek, Kyrgyzstan
DOI: https://doi.org/10.24321/0019.5138.2026104

I N F O

Corresponding Author:
Svetlana Chechetova, Department of Children's Infectious Diseases, IK Akhunbaev Kyrgyz State Medical Academy, Bishkek, Kyrgyzstan
E-mail Id:
svetlanachechetova25@gmail.com
Orcid Id:
https://orcid.org/0009-0008-5173-8503
How to cite this article:
Khalupko E, Chechetova S, Dzholbunova Z, Baialieva M, Radchenko E, Chynyeva D, Mambetova M, Omurkulova G, Imankulova C. Measles Vaccination Efficacy: Comparing Disease Severity and Complications in Kyrgyz Pediatric Patients. J Commun Dis. 2025;57(4):151-121.

Date of Submission: 2025-10-31
Date of Acceptance: 2025-11-24

A B S T R A C T

Introduction: Measles remains a global health challenge, particularly in regions with low vaccination rates.

Objective: This retrospective study examined measles progression in vaccinated and unvaccinated children in Kyrgyzstan during a resurgence between 2024 and 2025.

Methods: The study included 105 pediatric patients (aged 1-6 years) admitted to the Republican Clinical Infectious Diseases Hospital in Bishkek, categorized by vaccination status: Group I (unvaccinated, n=55) and Group II (vaccinated with at least one dose of measles-containing vaccine, n=50).

Results: Clinical presentation, complications, and treatment data were collected from the medical records. Results showed that unvaccinated children experienced more severe measles (67.3% vs. 38.0%, p<0.01) and had more complications (67.3% vs. 48.0%, p<0.05) than vaccinated children. Fever duration, hospital stay, and antibiotic treatment were longer in the unvaccinated children (p<0.001). Vaccination was associated with a 59% reduction in severe disease (RR=0.409) and complications (RR=0.403). The most common complication was pneumonia, affecting 87.3% of unvaccinated and 86.0% of vaccinated children.

Conclusion: The findings highlight the protective benefits of vaccination in reducing disease severity and complications, emphasizing the importance of high vaccination coverage to prevent outbreaks.

Keywords: Measles, vaccination, eradication, outbreak, Kyrgyzstan

Introduction

Despite widespread vaccination initiatives, measles remains a significant global public health challenge. The World Health Organization (WHO) has pledged to eradicate measles in all regions; however, as of 2023, none have achieved this goal. From 2000 to 2023, vaccination averted 60.3 million deaths. However, measles cases increased from 8.6 million to 10.3 million between 2022 and 2023, largely due to stagnant vaccination rates, with first-dose measles-containing vaccine (MCV) coverage remaining at 83%. Lower-income countries still face higher measles incidence.[1,2]

Measles remains a major cause of child mortality globally, particularly in areas with poor healthcare, such as sub-Saharan Africa. In these regions, control measures have reduced the number of measles cases. However, complete eradication remains challenging due to low vaccination coverage and outbreak spikes.[3]

In Kyrgyzstan, the situation reflects broader regional issues. In 2023, Kyrgyzstan, Azerbaijan, Kazakhstan, Romania, and the Russian Federation accounted for the majority of measles cases in the WHO European Region. This highlights the importance of maintaining high vaccination rates and effective surveillance systems to prevent future outbreaks. The measles resurgence in Kyrgyzstan highlights the need for political commitment to enhance vaccination and strengthen outbreak preparedness.[4]

Global initiatives to control and eradicate measles require sustaining vaccination rates above 95% to halt the spread of the disease. These initiatives involve catch-up vaccination campaigns, building vaccine trust, and reducing access barriers to vaccination. Although challenges exist, the highly effective vaccine makes measles potentially eradicable, provided global health systems ensure fair distribution and disease monitoring.[2,5]

Despite these improvements, measles remains a leading cause of death among children under the age of five.[6] The global coverage of MCVs reached 86% by 2019, up from 72% in 2000. COVID-19 caused rates to decline to 81% by 2021 and recover to 83% by 2022.[1] This decrease has led to an increase in measles cases and deaths, highlighting the need for vaccination coverage.[1,5]

In Kyrgyzstan, the challenges of measles control mirror global patterns. The rise in cases during the COVID-19 pandemic revealed weaknesses even in robust healthcare systems. Regions with low immunization rates are prone to outbreaks.[1] Measles elimination efforts focus on maintaining high vaccination rates through a two-dose MCV strategy.[5] Improving vaccine access, strengthening public health infrastructure, and reaching unvaccinated groups are crucial to address immunity gaps.[5,7]

Similar to many nations, Kyrgyzstan strives to meet these objectives; however, maintaining vaccine coverage to prevent measles transmission remains challenging. This requires renewed commitment to vaccination programs and healthcare system improvements to prevent disruptions, such as the pandemic, from eroding progress.

Vaccination is the only way to protect against measles. A single dose of the MMR vaccine protects approximately 93% of recipients, while two doses protect 97%.[8] However, in areas with low vaccination rates, even vaccinated individuals may encounter high viral loads, potentially causing illness, especially without a second dose.[9] The occurrence of disease in vaccinated individuals does not mean that the vaccine is ineffective.[10] This study aimed to examine measles progression in vaccinated patients and emphasize the importance of preventive vaccination.

Methods

A retrospective observational study evaluated the progression of measles in vaccinated and unvaccinated children. This study examined 105 medical records of pediatric patients, aged 1-6 years, who were admitted to the Republican Clinical Infectious Diseases Hospital, Bishkek, Kyrgyzstan, from 2024 to April 2025. During this period, the region experienced a surge in measles cases due to a decrease in vaccination rates. Researchers examined the medical records to gather epidemiological, clinical, and treatment-related data. This retrospective study allowed the evaluation of disease outcomes in real-world conditions, highlighting the effectiveness of MCV amid an active outbreak.

Patients were categorized into two groups based on vaccination status: Group I (Unvaccinated) included 55 unvaccinated children diagnosed with measles. Group II (Vaccinated) comprised 50 children with measles who received at least one MCV dose.

The inclusion criteria were children aged 0-8 years with a clinical and serological diagnosis of measles . The exclusion criteria were as follows: children aged > 8 years and those with incomplete records or unclear vaccination status.

Every measles case was confirmed through an enzyme-linked immunosorbent assay (ELISA) by identifying specific IgM antibodies targeting the measles virus.

The research staff manually gathered clinical data from patient charts and hospital records using a standardized extraction form. Fever was classified as mild (≤38°C), moderate (≤39°C), or severe (>39°C). Disease severity

ISSN: 0019-5138
DOI: https://doi.org/10.24321/0019.5138.2026104

was determined as moderate or severe based on clinical assessments in the medical records, including systemic symptoms, respiratory issues, and the need for intensive care. Complications were identified as secondary conditions during the rash phase, such as pneumonia, laryngotracheitis and obstructive bronchitis. The duration of antibiotic use and length of hospital stay were documented in days. Inter-rater reliability was evaluated during data extraction, and discrepancies were resolved by consensus under the guidance of a reviewer.

Age, onset of symptoms, fever patterns, Koplik spots, gastrointestinal or respiratory symptoms, rash characteristics, and complications were also recorded. Data on hospitalization days, antibiotic treatment duration, and discharge outcomes were gathered.

This study was conducted in accordance with the Declaration of Helsinki. Consent was obtained from the parents/guardians of the child participants. The Bioethics Committee of the Kyrgyz State Medical Academy named after I.K. Akhunbaev provided ethical approval (Protocol No. 2, dated April 19, 2017). Patient anonymity and confidentiality were maintained.

Data analysis was performed using SPSS version 25.0 (IBM Corp., Armonk, NY, USA). Descriptive statistics, such as the mean, standard deviation, and frequency percentages, were used to summarize the data. Comparative analyses between the two groups included the following methods: chi-square test (χ^2) for categorical variables, such as fever range, presence of complications, and disease severity; independent t-test for comparing continuous variables, such as fever duration and hospitalization days; odds ratio (OR) and relative risk (RR) were derived from four-field (2×2) contingency tables to evaluate the link between vaccination status and clinical outcomes; and Cramer's V coefficient was utilized to assess the strength of the relationship between vaccination status and both disease severity and complication rate. A p-value <0.05 was considered statistically significant, and confidence intervals (CI) were calculated at the 95% level.

Results

The age distribution showed notable differences between the groups. In Group I, children under 1 year were the majority at 36.3% (95% CI: 23.6%–49.0%), whereas none were present in Group II. The 1–3 years age bracket was the most common, with 41.8% (95% CI: 28.6%–55.0%) in Group I and 58.0% (95% CI: 44.2%–71.8%) in Group II. Children aged 4–6 years comprised 21.9% (95% CI: 11.1%–32.7%) in Group I and 26.0% (95% CI: 13.8%–38.2%) in Group II. Group II alone included children aged >6 years, at 16.0% (95% CI: 6.0%–26.0%) (Table 1).

In both groups, patients exhibited typical measles symptoms, including fever, maculopapular rash, and catarrhal signs. Nearly all patients showed conjunctivitis, light sensitivity, and a runny nose upon admission. The average time from symptom onset to hospital admission was shorter for vaccinated children (4.0 ± 1.3 days) than for unvaccinated children (7.0 ± 1.5 days). This suggests that milder initial symptoms in vaccinated individuals led them to seek medical attention sooner. The average hospital stay was shorter for vaccinated children (7.5 ± 2.4 days) compared to unvaccinated children (10.2 ± 3.1 days), with a statistically significant difference ($p < 0.001$). These results show that vaccination lessens disease severity and decreases the need for healthcare services.

The patients received care in an infectious disease unit. The illness had an acute onset, with intoxication and catarrhal signs. Patients were hospitalized on days 4.0 ± 1.3 and 7.0 ± 1.5 of illness, respectively. Disease severity varied according to vaccination status. In unvaccinated children (Group I, n = 55), 67.3% (95% CI: 54.9%–79.7%) experienced severe measles, whereas in vaccinated children (Group II, n = 50), this was 38.0% (95% CI: 24.6%–51.4%) ($p < 0.01$). Moderate measles was more prevalent among vaccinated children (62.0%) than among unvaccinated children (32.7 %) ($p < 0.01$) (Table 2).

No significant differences were observed in the highest temperatures recorded between the groups. In Group I, 18.2% (95% CI: 9.3%–27.1%) experienced fevers up to 38°C, 67.3% (95% CI: 55.1%–78.7%) had fevers up to 39°C, and 14.5% (95% CI: 5.7%–25.2%) exceeded 39°C. In Group II, the percentages were 24.0% (95% CI: 12.3%–35.7%), 60.0% (95% CI: 46.5%–73.5%), and 16.0% (95% CI: 5.6%–26.4%) ($\chi^2 = 0.66$; $p > 0.05$). However, fever lasted longer in unvaccinated children (7.0 ± 2.3 days) than in vaccinated children (4.0 ± 1.3 days) ($t = 8.33$; $p < 0.001$) (Table 3).

Typical symptoms include conjunctivitis, scleritis, a runny nose, tearing, coughing, and sensitivity to light. Koplik spots appeared 1–2 days before the rash in 67.2% (95% CI: 54.8%–79.6%) of unvaccinated children and 90.0% (95% CI: 81.7%–98.3%) of those who were vaccinated. The increased visibility in vaccinated children may be attributed to less severe systemic intoxication, allowing for earlier detection.

Among unvaccinated children, 50.9% (95% CI: 37.7%–64.1%) had diarrhea, which was likely linked to a younger age. Only 8.0% (95% CI: 0.5%–15.5%) of vaccinated children had diarrhea. During the catarrhal phase, 24.0% (95% CI: 12.2%–35.8%) of the vaccinated children had acute stenosing laryngotracheitis.

The rash emerged on day three of illness (SD: 1.2 days), appearing on the face and then progressing downward. In 98.0% of the cases, it manifested as a maculopapular rash.

ISSN: 0019-5138
DOI: https://doi.org/10.24321/0019.5138.2026104

Unvaccinated children exhibited a more severe rash with increased intoxication symptoms at onset ($p < 0.001$). The rash phase lasted 3.5 ± 1.6 days in both groups.

Complications were more prevalent among unvaccinated children, occurring in 67.3% (95% CI: 54.8%–79.8%) versus 48.0% (95% CI: 34.2%–61.8%) of vaccinated children (Z test, $p < 0.05$) (Table 4).

Pneumonia was the most frequent complication, affecting 87.3% (95% CI: 78.5%–96.1%) of unvaccinated and 86.0% (95% CI: 76.4%–95.6%) of vaccinated children. Croup occurred in 9.1% (95% CI: 1.5%–16.7%) of unvaccinated children versus 4.0% (95% CI: –1.4%–9.4%) of vaccinated ones. Obstructive bronchitis appeared in 1.8% (95% CI: –1.7%–5.3%) of unvaccinated and 8.0% (95% CI: 0.5%–15.5%) of vaccinated children (Table 4).

Table 1. Age distribution of measles cases in group I and group II

S No	Age group	Group I %, (95% CI)	Group II %, (95% CI)
1.	<1 year	36.3 (23.6–49.0)	-
2.	1-3 years	41.8 (28.6–55.0)	58.0 (44.2–71.8)
3.	4-6 years	21.9 (11.1–32.7)	26.0 (13.8–38.2)
4.	>6 years	-	16.0 (6.0–26.0)

95% CI – 95% confidence interval

Table 2.Disease severity by vaccination status

S No	Severity	Unvaccinated group I %, (95% CI)	Vaccinated group II %, (95% CI)
1.	Severe	67.3 (54.9–79.7)	38.0 (24.6–51.4)
2.	Moderate	32.7	62.0

95% CI – 95% confidence interval

Table 3.Distribution of temperature levels during measles

S No	Temperature level	Group I %, (95% CI)	Group II %, (95% CI)
1.	≤ 38°C	18.2 (9.3–27.1)	24.0 (12.3–35.7)
2.	≤ 39°C	67.3 (55.1–78.7)	60.0 (46.5–73.5)
3.	> 39°C	14.5 (5.7–25.2)	16.0 (5.6–26.4)

95% CI – 95% confidence interval

Table 4.Frequency of complications during the rash phase

S No	Complications	Unvaccinated group I %, (95% CI)	Vaccinated group II %, (95% CI)
1.	Any complication	67.3 (54.8–79.8)	48.0 (34.2–61.8)
2.	Pneumonia	87.3 (78.5–96.1)	86.0 (76.4–95.6)
3.	Croup	9.1 (1.5–16.7)	4.0 (–1.4–9.4)
4.	Obstructive bronchitis	1.8 (–1.7–5.3)	8.0 (0.5–15.5)

95% CI – 95% confidence interval

Children received symptomatic care, including antipyretics, fluid therapy, and vitamin supplements. Antibiotics were prescribed for patients with bacterial complications, mainly pneumonia. The average antibiotic treatment duration was longer in the unvaccinated group (9.1 ± 2.4 days) than in the vaccinated group (7.3 ± 1.9 days), indicating a higher incidence of complications in the former. No patient required intensive care, and there were no deaths in either group. All the children recovered and were discharged in good condition. The outcomes in both groups were attributed to prompt hospital care; however, the lower disease burden in vaccinated children highlights the protective benefits of immunization against severe measles.

Measles was confirmed by ELISA IgM detection. All children received supportive care, and those with pneumonia were administered antibiotics for 8 ± 2.6 days. On average, they were discharged after 9 ± 3.0 days.

Vaccination status was associated with less severe illness and fewer complications. Unvaccinated children had a

ISSN: 0019-5138
DOI: https://doi.org/10.24321/0019.5138.2026104

threefold higher risk of severe measles (OR = 3.354) and were 2.27 times more likely to develop complications (OR = 2.27). Vaccination decreased the likelihood of severe disease and complications by more than 59% (RR = 0.409 and 0.403, respectively). Statistical analysis confirmed these results ($\chi^2 = 8.71$, $p = 0.003$ for disease severity; and $\chi^2 = 3.99$, $p = 0.046$ for complications). The association between vaccination and disease severity was moderately strong (Cramer's V = 0.293), whereas it was weaker for complications (Cramer's V = 0.195).

Discussion

This study demonstrates the clinical advantages of measles vaccination in reducing disease severity and complications in children. Despite worldwide vaccination efforts, measles remains a major contributor to childhood illness and death, particularly in areas with low immunization rates, such as Kyrgyzstan. Our results showed that vaccinated children experienced milder illness, shorter hospitalizations, fewer complications, and reduced fever duration and antibiotic use compared with unvaccinated children. These findings align with those of existing studies on the protective benefits of MCVs.[11–13]

Measles reemerged in Kyrgyzstan during 2024–2025, due to decline in routine vaccinations caused by the COVID-19 pandemic disruptions. This reflects a global pattern in which MCV coverage fell from 86% in 2019 to 81% in 2021, with a recovery to 83% in 2022.14,15 The WHO recommends a coverage rate of≥95% for MCV to achieve herd immunity; however, few areas reach this level, leaving populations vulnerable to outbreaks.[6] Our study confirms these concerns, as most of study group comprised unvaccinated children who showed higher rates of severe illness and complications.

Vaccinated children had a shorter hospital stay of 7.5 days versus 10.2 days for unvaccinated children, and their clinical progression was less severe, consistent with global surveillance data and studies.[17,18] A study in England showed that vaccinated individuals with measles had milder symptoms and were less likely to develop complications, such as pneumonia or require hospitalization.[19] In our study, vaccinated children sought medical attention earlier, with fewer symptomatic days before hospitalization than unvaccinated children. This may be due to milder initial symptoms prompting earlier caregiver action or heightened health awareness among families with vaccinated children.

The most common complications were pneumonia, croup, and obstructive bronchitis. Although pneumonia rates were elevated in both groups, they were marginally higher in unvaccinated children. This suggests that while the vaccine may not prevent infection in every case, it plays a crucial role in reducing the risk of secondary bacterial infections and severe respiratory complications.[20] Additionally, vaccinated children experienced fewer gastrointestinal symptoms like diarrhea, aligning with earlier studies that reported reduced systemic inflammatory response in vaccinated individuals.[21]

Children who received vaccinations showed a 59% lower risk of severe illness (RR = 0.409) and complications (RR = 0.403). These results align with data from the WHO and the Centers for Disease Control and Prevention, showing that two doses of the vaccine prevent severe measles with an effectiveness rate of over 90%.[12,22] The moderate association (Cramer's V = 0.293 for severity) shows that vaccination remains a predictor of clinical outcomes during outbreaks.

Koplik spots were more commonly seen in vaccinated children. This could be due to less severe disease progression, making it easier to identify early signs before severe symptoms appear. This observation could help frontline healthcare workers identify breakthrough cases during outbreaks and provide early treatment to patients.

Unvaccinated children face higher rates of complications and fever, showing increased vulnerability to inflammation and immune system disruption due to measles. Measles causes immune amnesia, which diminishes previously acquired immunity and increases susceptibility to other infections.[23] This process emphasizes the need for early vaccination to provide protection.

Our research has significant implications for public health policy in Kyrgyzstan and similar environments. This highlights the need to enhance vaccination initiatives, broaden catch-up efforts, and foster community confidence in vaccines. Political dedication and global cooperation are crucial for strengthening surveillance systems, tackling vaccine hesitancy, and reaching underserved populations.[24]

The high incidence of complications among unvaccinated children places a significant burden on healthcare systems. Supporting vaccination is crucial for saving lives and proves cost-effective in decreasing hospital stays and antibiotic use.[25]

Recent studies from Kyrgyzstan have highlighted measles as a major health concern for children, despite vaccination initiatives. Chechetova et al. found that hospitalized pediatric cases showed increased proinflammatory cytokines IL6, IL10, and TNF-α, linked to disease severity and immunosuppression.[26] Chechetova et al. analyzed 72 children with moderate-to-severe measles and found reduced CD3+, CD4+, CD8+, and CD16+ lymphocytes compared to healthy individuals. Younger children had more severe disease (r = -0.3), and 86% were unvaccinated.[27] A review by Chechetova et al. noted an increase in outbreaks due to declining vaccination rates, highlighting the ability of measles to deplete immune memory. The authors

ISSN: 0019-5138
DOI: https://doi.org/10.24321/0019.5138.2026104

recommended achieving ≥95% vaccination coverage.[28] These findings demonstrate that measles remains deadly in under-vaccinated populations where immunological vulnerability persists.

This study has limitations in interpreting the results. First, the retrospective nature of the study relied on the precision of medical records, which could have caused information bias or underreporting. Second, the small sample size from one tertiary infectious disease hospital in Bishkek may limit its applicability to other regions. Third, vaccination status may contain recall inaccuracies, especially in partially vaccinated children, as recorded in medical records or reported by parents. Fourth, this study did not evaluate laboratory-confirmed viral loads or immunological markers that might provide insights into vaccine-influenced immune responses. Finally, factors such as nutrition, coexisting conditions, and socioeconomic status were not controlled for, which could have affected disease outcomes. Future prospective multicenter studies with immunological profiling are needed to confirm these findings.

Based on the results of this study, several public health recommendations can be made. First, efforts should be intensified to achieve 95% measles vaccination coverage through regular immunization and targeted campaigns, focusing on under-vaccinated populations. Second, resources should be allocated to community engagement to foster vaccine trust, counter misinformation, and address hesitancy in underserved communities. Third, healthcare systems must strengthen surveillance for the early identification of measles outbreaks. Fourth, combining measles vaccination with other child health initiatives, such as nutrition and maternal care, could improve accessibility. Fifth, training should be provided to primary healthcare providers to recognize atypical measles cases and ensure prompt treatment. Finally, research should be conducted to investigate immune responses following measles infection in vaccinated and unvaccinated children to inform future vaccination strategies.

Conclusions

This study demonstrates that previously administered measles vaccinations reduce illness severity, decrease hospital stays and fevers, and lower the risk of complications in children during outbreaks. Future studies should focus on immunological profiling to understand vaccine-induced protection and to inform vaccination policies.

Source of Funding: None

Conflict of Interest: None

Authors' Contribution: Conceptualization, Elena Khalupko, Svetlana Chechetova, and Zuura Dzholbunova; methodology, Meerim Baialieva, and Elena Radchenko; data collection, Damirakhan Chynyeva, and Madina Mambetova; writing—original draft preparation, Gulzhan Omurkulova, Cholpon Imankulova, Elena Khalupko, and Svetlana Chechetova; writing—review and editing, Elena Khalupko, and Svetlana Chechetova. All authors have read and agreed to the published version of the manuscript.

Declaration of Generative AI and AI-Assisted Technologies in the Writing Process: None

References

1. Minta AA. Progress toward measles elimination—worldwide, 2000–2022. MMWR. Morbidity and Mortality Weekly Report. 2023;72. [Google Scholar] [Pubmed]
2. Minta AA. Progress toward measles elimination—worldwide, 2000–2022. MMWR. Morbidity and Mortality Weekly Report. 2023;72. [Google Scholar] [Pubmed]
3. Moss WJ, Griffin DE. Global measles elimination. Nature Reviews Microbiology. 2006 Dec;4(12):900-8. [Google Scholar] [Pubmed]
4. Muscat M, Ben Mamou M, Reynen-de Kat C, Jankovic D, Hagan J, Singh S, Datta SS. Progress and challenges in measles and rubella elimination in the WHO European region. Vaccines. 2024 Jun 20;12(6):696. [Google Scholar] [Pubmed]
5. Gastañaduy PA, Goodson JL, Panagiotakopoulos L, Rota PA, Orenstein WA, Patel M. Measles in the 21st century: progress toward achieving and sustaining elimination. The Journal of infectious diseases. 2021 Oct 1;224(Supplement_4):S420-8. [Google Scholar] [Pubmed]
6. Strebel P, Cochi S, Grabowsky M, Bilous J, Hersh BS, Okwo-Bele JM, Hoekstra E, Wright P, Katz S. The unfinished measles immunization agenda. Journal of Infectious Diseases. 2003 May 15;187(Supplement_1):S1-7. [Google Scholar] [Pubmed]
7. Patel MK, Antoni S, Nedelec Y, Sodha S, Menning L, Ogbuanu IU, Gacic Dobo M. The changing global epidemiology of measles, 2013–2018. The Journal of infectious diseases. 2020 Sep 1;222(7):1117-28. [Google Scholar] [Pubmed]
8. Leung J, Munir NA, Mathis AD, Filardo TD, Rota PA, Sugerman DE, Sowers SB, Mercader S, Crooke SN, Gastañaduy PA. The effects of vaccination status and age on clinical characteristics and severity of measles cases in the United States in the postelimination era, 2001–2022. Clinical Infectious Diseases. 2025 Mar 15;80(3):663-72. [Google Scholar] [Pubmed]
9. Crowcroft NS, Minta AA, Bolotin S, Cernuschi T, Ariyarajah A, Antoni S, Mulders MN, Bose AS, O'Connor PM. The problem with delaying measles elimination. Vaccines. 2024 Jul 22;12(7):813. [Google Scholar] [Pubmed]

ISSN: 0019-5138
DOI: https://doi.org/10.24321/0019.5138.2026104

10. Rubis LV. A survey of examining herd measles immunity in adults over 35 years old. Russian Journal of Infection and Immunity. 2020 Apr 17;10(2):381-6. [Google Scholar]
11. Patel MK. Progress toward regional measles elimination—worldwide, 2000–2018. MMWR. Morbidity and mortality weekly report. 2019;68. [Google Scholar] [Pubmed]
12. Patel MK, Goodson JL, Alexander JP Jr, Kretsinger K, Sodha SV, Steulet C, et al. Progress Toward Regional Measles Elimination - Worldwide, 2000-2019. MMWR Morb Mortal Wkly Rep. 2020;69(45):1700-1705. [Pubmed]
13. Dixon MG. Progress toward regional measles elimination—worldwide, 2000–2020. MMWR. Morbidity and mortality weekly report. 2021;70. [Google Scholar] [Pubmed]
14. Causey K, Fullman N, Sorensen RJ, Galles NC, Zheng P, Aravkin A, Danovaro-Holliday MC, Martinez-Piedra R, Sodha SV, Velandia-González MP, Gacic-Dobo M. Estimating global and regional disruptions to routine childhood vaccine coverage during the COVID-19 pandemic in 2020: a modelling study. The Lancet. 2021 Aug 7;398(10299):522-34. [Google Scholar] [Pubmed]
15. World Health Organization. Immunization coverage. https://www.who.int/news-room/fact-sheets/detail/immunization-coverage. Accessed July 25, 2025.
16. Strebel PM, Cochi SL, Hoekstra E, Rota PA, Featherstone D, Bellini WJ, Katz SL. A world without measles. The Journal of infectious diseases. 2011 Jul 1;204(suppl_1):S1-3. [Google Scholar] [Pubmed]
17. Biellik RJ, Orenstein WA. Strengthening routine immunization through measles-rubella elimination. Vaccine. 2018 Sep 5;36(37):5645-50. [Google Scholar] [Pubmed]
18. Portnoy A, Jit M, Helleringer S, Verguet S. Impact of measles supplementary immunization activities on reaching children missed by routine programs. Vaccine. 2018 Jan 2;36(1):170-8. [Google Scholar] [Pubmed]
19. Perry RT, Halsey NA. The clinical significance of measles: a review. The Journal of infectious diseases. 2004 May 1;189(Supplement_1):S4-16. [Google Scholar] [Pubmed]
20. Mina MJ, Metcalf CJ, De Swart RL, Osterhaus AD, Grenfell BT. Long-term measles-induced immunomodulation increases overall childhood infectious disease mortality. Science. 2015 May 8;348(6235):694-9. [Google Scholar] [Pubmed]
21. Griffin DE. Measles virus-induced suppression of immune responses. Immunological reviews. 2010 Jul;236(1):176-89. [Google Scholar] [Pubmed]
22. CDC: Centers for Disease Control and Prevention. Measles, Mumps, and Rubella (MMR) Vaccine. https://www.cdc.gov/vaccines/hcp/vis/vis-statements/mmr.html. Accessed July 25, 2025.
23. Petrova VN, Sawatsky B, Han AX, Laksono BM, Walz L, Parker E, Pieper K, Anderson CA, de Vries RD, Lanzavecchia A, Kellam P. Incomplete genetic reconstitution of B cell pools contributes to prolonged immunosuppression after measles. Science immunology. 2019 Nov 1;4(41):eaay6125. [Google Scholar] [Pubmed]
24. Gavi, the Vaccine Alliance. Catching up on missed vaccinations. https://www.gavi.org/vaccineswork. Accessed July 25, 2025.
25. Nandi A, Shet A. Why vaccines matter: understanding the broader health, economic, and child development benefits of routine vaccination. Human vaccines & immunotherapeutics. 2020 Aug 2;16(8):1900-4. [Google Scholar] [Pubmed]
26. Chechetova S, Kadyrova R, Dzholbunova Z, Mainazarova E, Khalupko E, Radchenko E, Chynyeva D, Mambetova M, Shaiymbetov A, Tagaev10 T. Cytokine Profiles and Disease Severity in Measles: A Prospective Observational Study. J. Commun. Dis. 2025;57(2):37-44. [Google Scholar]
27. Chechetova S, Kadyrova R, Dzholbunova Z, Khalupko E, Mainazarova E, Vityala Y, Tagaev T. Immunological features of measles in children. Journal of Communicable Diseases. 2021;53(3):11-5. [Google Scholar]
28. Chechetova S, Kadyrova R, Dzholbunova Z, Khalupko E, Radchenko E, Yethindra V, Tagaev T, Kanteti KP. Measles in children: a re-emergence of the vaccine-preventable disease. Biomedicine. 2022 Sep 12;42(4):647-50. [Google Scholar]

ISSN: 0019-5138
DOI: https://doi.org/10.24321/0019.5138.2026104